How the Tumbleweed Rover works

The familiar rovers - Sojourner, Spirit and Opportunity - use wheels driven by a power source. This is a good system for precise placement of science instruments over a short distance on a smooth terrain. The wheels are mechanisms subject to the effects of abrasive dust and soil. The larger Tumbleweed Rover have the potential to roll over rocks and into canyons.

The power source for the more familiar rovers must be carried from the surface of Earth to the surface of Mars. The Tumbleweed Rover uses a natural power source the wind which is available on Mars as on Earth. Using wind propulsion means that the distance a Tumbleweed travels is not limited by its power supply. This ability to travel long distances makes the Tumbleweed a good candidate for surface survey missions, such as mapping the Mars environment over large areas.

One way to think about it is exploration by boat, a power boat can travel a short distance before running out of fuel, a sail boat has potential to circle the Earth pushed by the wind. Explorers of the past centuries used sailing ships to travel long distances the Earth, Tumbleweeds will use a similar technique to travel long distances on Mars.

To travel by wind power the aerodynamic properties of the tumbleweed must be known. Wind tunnel tests help determine properties such as drag and lift for the concept models. The Tumbleweed must also roll easily. Roll tests of various concepts determine how much aerodynamic force is needed to move the Tumbleweed. These are some of the factors in determining the best type of Tumbleweed for a given mission.

Another factor is the amount of control needed to accomplish the mission. Different science missions will require different levels of control. We have identified 4 generations of controls for the Tumbleweed Rovers:

1. No controls - these Tumbleweeds go with the wind
2. Start/Stop control - as 1, add the ability to stop to take and transmit data and for navigation updates
3. Start/Stop/Maneuver - as 2, add the ability to steer toward a specific site with potential to group together
4. Start/Stop/Maneuver/Point at targets - as 3, add the ability to point to interesting locations without moving

How the Tumbleweed Rover works

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Wind Tunnel testing of Tumbleweed concept models.

Wind tunnel tests were performed at the Langley Research Center's Basic Aerodynamic Research Tunnel (BART) to compare the aerodynamic characteristics, lift and drag coefficient, of the various designs.
Wind tunnel tests were also performed by the aerospace engineering students at North Carolina State University (NCSU) and by students and faculty at Texas Technical University (TTU). These results of these tests are used to continue the refinement of the Tumbleweed models.

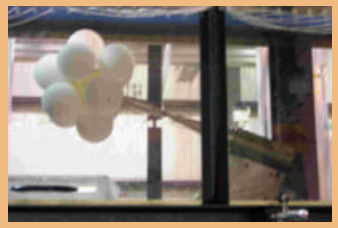
Tumbleweed Tests in the BART


Tumbleweed

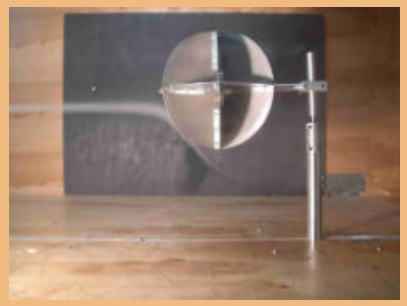

Dandelion


TumbleCup


Box Kite


Airbags


James McGrew installs the calibration sphere in the NCSU wind tunnel


TTU Box Kite Smoke Flow Test

How the Tumbleweed Rover works

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Dynamics testing of Tumbleweed concept models.

An early test run.

Preparing to release the targeted calibration sphere

Dynamics tests were performed at the Langley Research Center to determine the rolling and bouncing characteristics of the various designs. The data from these tests will be input to a computer simulation to predict the behavior of the Tumbleweeds under Martian gravity and atmospheric conditions.

A system calibration run

The test models are outfitted with coded “targets” for videogrametric motion analysis. This is a 3-D analysis technique using multiple, synchronized video cameras to determine the position of the targets. A frame by frame comparison of the target positions can give the position of the model and rotation of the model for each time step. The time step is defined by the camera speed, such as 30 frames per second. Knowing the time step, relative position and rotation of the model for each frame the velocity, rotation rate, accelerations and forces can be computed.

For our rolling resistance tests the model is released from the top of an inclined plane (ramp) and allowed to roll down. The ramp angle and the model velocity are measured and compared to the effects of gravity. The difference is the rolling resistance plus aerodynamic effects. Aerodynamic effects are obtained from wind tunnel tests.

Rachel Owens and Mike Wisniewski run roll tests.
Summer 2003

During the summer of 2003, students tested a variety of models in preliminary dynamics tests to verify assumptions in the dynamics simulation model. Their experiments used a ramp with a grid background videotaped on a single camera. These tests helped determine techniques to be used in the later tests.

How the Tumbleweed Rover works

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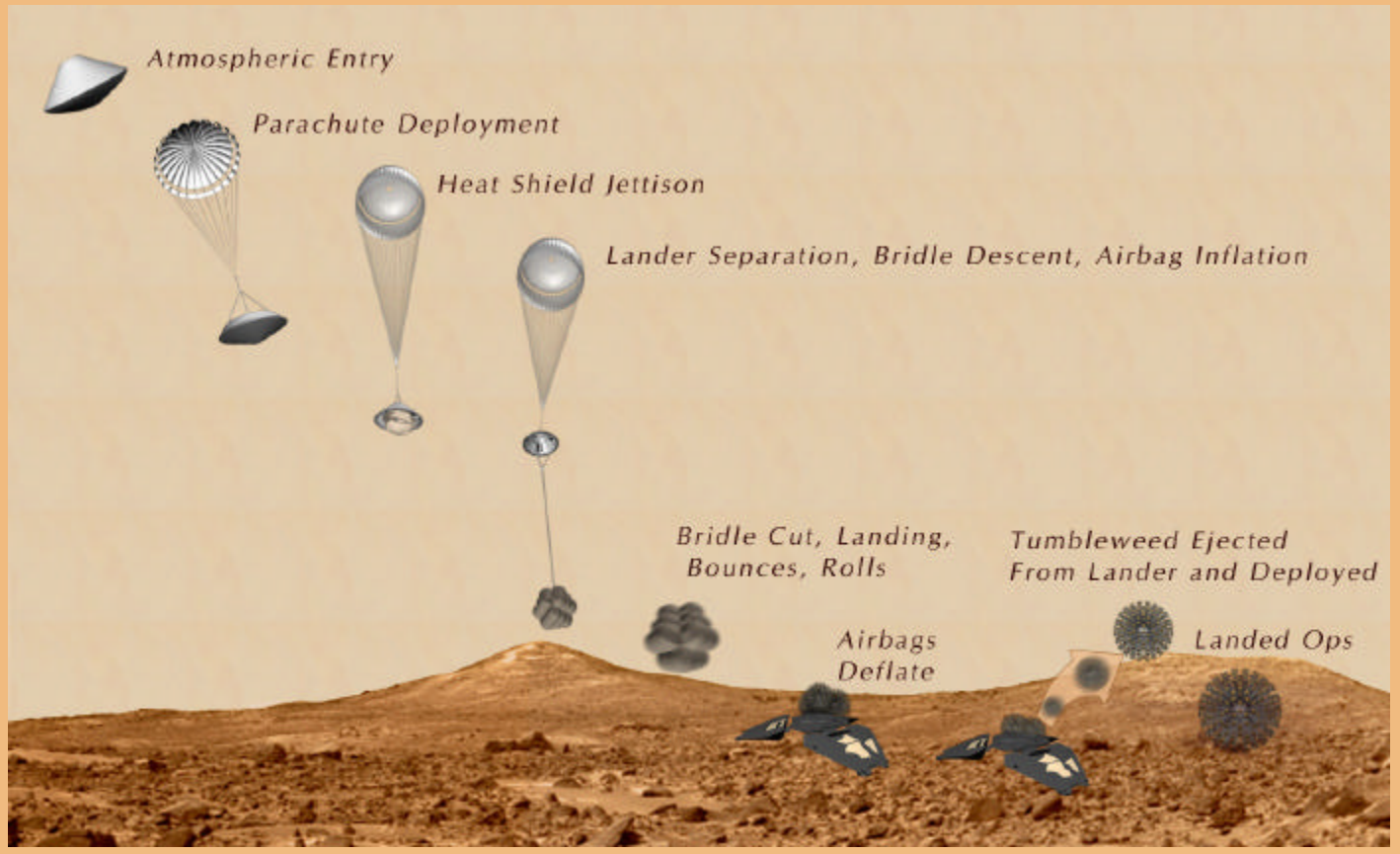
Tumbleweed Deployment Option 1 - Using Proven Airbag Landing System



Tumbleweed rovers could be deployed at the entrance to a valley or canyon and allowed to be driven into the region by the wind.

Tumbleweeds could also be deployed near the top of a valley, canyon, or crater and be blown by the wind down the slopes into the area of interest.